Phase Transition Phenomena in a Radial Force Field in CO_2 under Low Gravity

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Phase transition in simple fluids is driven on earth by gravity-induced flows that are often turbulent. Experiments under reduced gravity (onboard sounding rockets, the space shuttle and the Mir station) prevents these effects and show that the behavior of phase separating fluids, after scaling by proper length and time units related to their critical point, obeys only two growth laws. We here present new data that support this behavior and cover almost 12 decades in scaled time.

The evolution of the pattern is driven by multiple coalescence of drops or bubbles, caused by Brownian motion and/or hydrodynamics interactions. At small volume fraction (ϕ < 0.3), Brownian diffusion dominates the coalescence rate. The role of such coalescence events is demonstrated in a phase separation experiment at small ϕ (<20%) in CO_2 at off-critical density $\delta\rho/\rho_c$ = 9.4% (ρ is density, ρ_c is the critical density), performed onboard the Mir station. A laser beam is sent into the sample where it perturbs the phase separation process by inducing a semi-radial temperature profile centered on the entrance window. The resulting thermo-capillary (Marangoni) effect attracts the bubbles toward the center of the beam. At the beginning of the phase separation, a vapor bubble is trapped at the center of the beam. The surrounding bubbles are also attracted to the center. They gradually fuse together and are eventually captured by the central bubble. It results in a unique central bubble that grows faster than the surrounding bubbles and at the expense of the surrounding bubbles.